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# Network Functions and Facilities

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*The objectives, functions, and organization of the Deep Space Network are summarized; tracking complexes, ground communications, and network operations control capabilities are described.*

The Deep Space Network (DSN) was established by the National Aeronautics and Space Administration (NASA) Office of Space Tracking and Data Systems and is under the system management and technical direction of the Jet Propulsion Laboratory (JPL). The network is designed for two-way communications with (1) unmanned spacecraft traveling from earth to the planets and to the edge of our solar system, (2) unmanned satellites orbiting the earth, and (3) manned space shuttle missions. It has provided tracking and data acquisition support for a large number of deep space and earth orbiting exploration projects as listed in Table 1.

From its inception, NASA has had the objective of conducting scientific investigations throughout the solar system. It was recognized that in order to meet this objective, significant supporting research and advanced technology development must be conducted in order to provide deep space telecommunications for science data return in a cost effective manner. Therefore, the Network is continually evolving to keep pace with the state of the art of telecommunications and data handling. It was also recognized early that close coordination would be needed between the requirements of the flight projects for data return and the capabilities needed in the Network. This close collaboration is effected by the appointment of a Tracking and Data Systems Manager as part of the flight project team from the initiation of the project to the end of the mission. By this process, requirements are identified early enough to provide funding and implementation in time for use by the flight project in its flight phase.

The computer software necessary for the network operations control and monitor functions operates in computers that are configured in parallel to project data processing computers. A characteristic of the interface is that the Network provides direct data flow to and from the complexes, namely, metric data, command data science and engineering telemetry, and such network monitor data as are useful to the flight project. This is done via appropriate ground communication equipment to mission operations centers, wherever they may be.

The principal deliverables to the users of the Network are carried out by data system configurations as follows:

(1) The DSN Tracking System generates radio metric data, i.e., angles, one- and two-way doppler and range, and VLBI, and delivers magnetic tape data records to Mission Control.

(2) The DSN Telemetry System receives, decodes, records, and retransmits engineering and scientific data from the spacecraft to Mission Control via the Ground Communication Facility.

(3) The DSN Command System accepts spacecraft commands from Mission Control and transmits the commands via the Ground Communication Facility to a Deep Space Station. The commands are then radiated to the spacecraft in order to initiate spacecraft functions in flight.

(4) The DSN Radio Science System generates radio science data, i.e., the frequency and amplitude of spacecraft transmitted signals affected by passage through media such as the solar corona, planetary atmospheres, and planetary rings, and delivers magnetic tape data record to Mission Control.

The data system configurations supporting testing, training, and network operations control functions are as follows:

(1) The DSN Monitor and Control System instruments, transmits, records, and displays those parameters of the DSN necessary to verify configuration and validate the Network performance. It provides the tools necessary for Network Operations personnel to control and monitor the Network and interface with flight project mission control personnel.

(2) The DSN Test and Training System generates and controls simulated data to support development, test, training and fault isolation within the DSN. It participates in mission simulation with flight projects.

The capabilities needed to carry out the above functions have evolved in three technical areas:

(1) The Deep Space Complexes, which are distributed around the Earth at approximately 120° longitudinal separation in order to provide near continuous coverage of Deep Space missions. The technology involved in equipping these stations is strongly related to the state of the art of telecommunications and flight-ground design considerations, and is multimission in character.

(2) The Ground Communications Facility provides the capability required for the transmission, reception, and monitoring of Earth-based, point-to-point communications between the stations and the Network Operations Control Center at JPL, Pasadena, and to the JPL Mission Operations Centers. Four communications disciplines are provided: teletype, voice, high-speed, and wideband.

The Ground Communications Facility uses the capabilities provided by common carriers throughout the world, engineered into an integrated system by NASA Communications (NASCOM) which is managed by the Goddard Space Flight Center, and controlled from the Communications Center located in the Space Flight Operations Facility (Building 230) at JPL.

The Network Operations Control Center is the functional entity for centralized operational control of the Network and interfaces with the users. It has two separable functional elements: namely, Network Operations Control and Network Data Processing. The functions of the Network Operations Control are as follows:

Control and coordination of Network support to meet commitments to Network users.

Utilization of the Network data processing computing capability to generate all standards and limits required for Network operations.

Utilization of Network data processing computing capability to analyze and validate the performance of all Network systems.

The personnel who carry out the above functions are located in the Space Flight Operations Facility. Network personnel are directed by an Operations Control Chief. The functions of the Network Data Processing are as follows:

Processing of data used by Network Operations Control for control and analysis of the Network.

Display in the Network Operations Control Area of data processed in the Network Data Processing Area.

Interface with communications circuits for input to and output from the Network Data Processing Area.

Data logging and production of the intermediate data records.

The personnel who carry out these functions are also located in the Space Flight Operations Facility. The equipment consists of minicomputers for real-time data system monitoring, XDS Sigma 5s, VAX 11/780s, magnetic tape recorders, and appropriate interface equipment with ground data communications.

**Table 1. Projects supported by the DSN**

| Mission | Project Management | Mission Operations |
|---|---|---|
| Ranger | JPL | JPL |
| Surveyor | JPL | JPL |
| Mariner Venus 1962 | JPL | JPL |
| Mariner Mars 1964 | JPL | JPL |
| Mariner Venus 1967 | JPL | JPL |
| Mariner Mars 1969 | JPL | JPL |
| Mariner Mars 1971 | JPL | JPL |
| Mariner Venus-Mercury 1973 | JPL | JPL |
| Voyager Jupiter-Saturn-Uranus | JPL | JPL |
| Lunar Orbiter | Langley Research Center | Langley Research Center |
| Pioneer | Ames Research Center | Ames Research Center |
| Apollo | Johnson Space Center | Johnson Space Center |
| Helios | German Spaceflight Operations Center | German Spaceflight Operations Center |
| Viking | Langley Research Center | Langley Research Center |
| Giotto | European Space Agency | European Space Agency |
| Sakigake | Institute of Space and Astronautical Science | Institute of Space and Astronautical Science |
| Suisei | Institute of Space and Astronautical Science | Institute of Space and Astronautical Science |
| International Cometary Explorer | Goddard Space Flight Center | Goddard Space Flight Center |
| Nimbus-7 | Goddard Space Flight Center | Goddard Space Flight Center |
| Dynamic Explorer-1 | Goddard Space Flight Center | Goddard Space Flight Center |
| International Sun-Earth Explorers 1 and 2 | Goddard Space Flight Center | Goddard Space Flight Center |
| Shuttle | Johnson Space Center | Johnson Space Center |